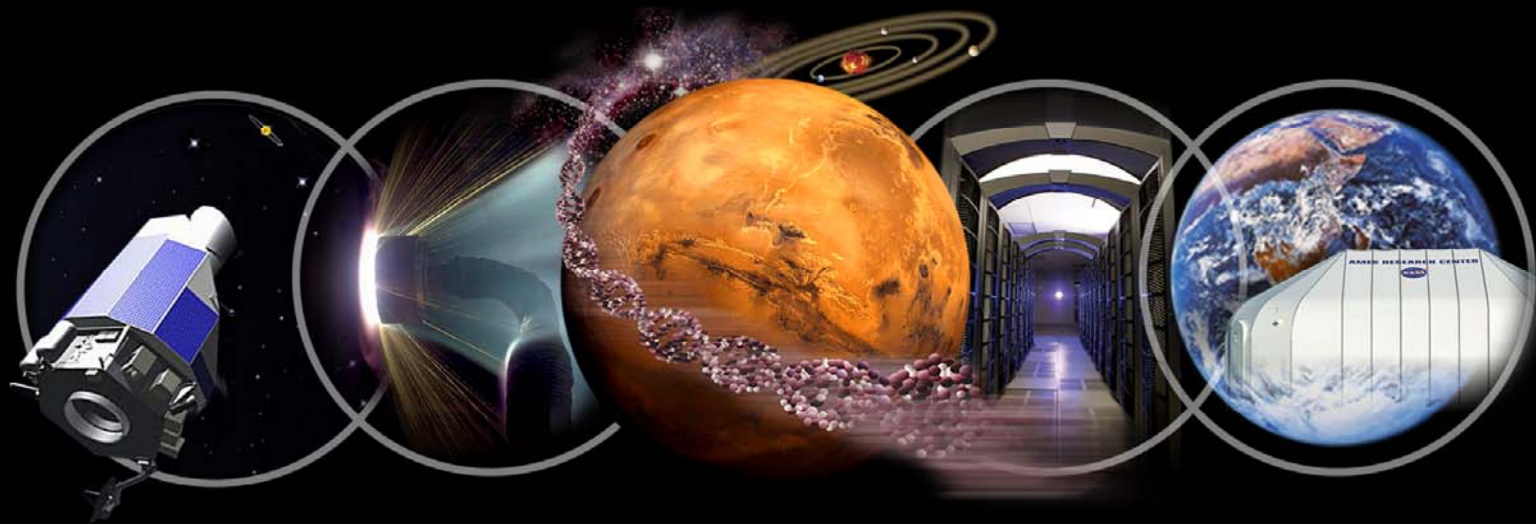
Discovery ➲ Innovation ➲ Solutions



Autonomous Systems and Robotics

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Ames Exploration Systems Technology Partnerships Forum

July 22-23, 2004

Visibility ➲ Excellence ➲ Impact

Ames Research Center

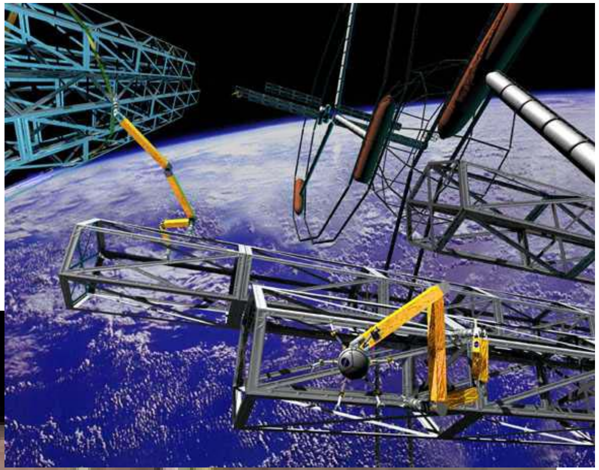
Autonomy and Robotics in Exploration

The Exploration Initiative makes a clear commitment to joint human/robot exploration

- Robotic precursors
- Robotic assistants

Autonomy is called out as a critical H&RT challenge

- Risk reduction
- Self-sufficiency
- Reduced operations costs



Autonomy and Robotics at Ames

Expertise

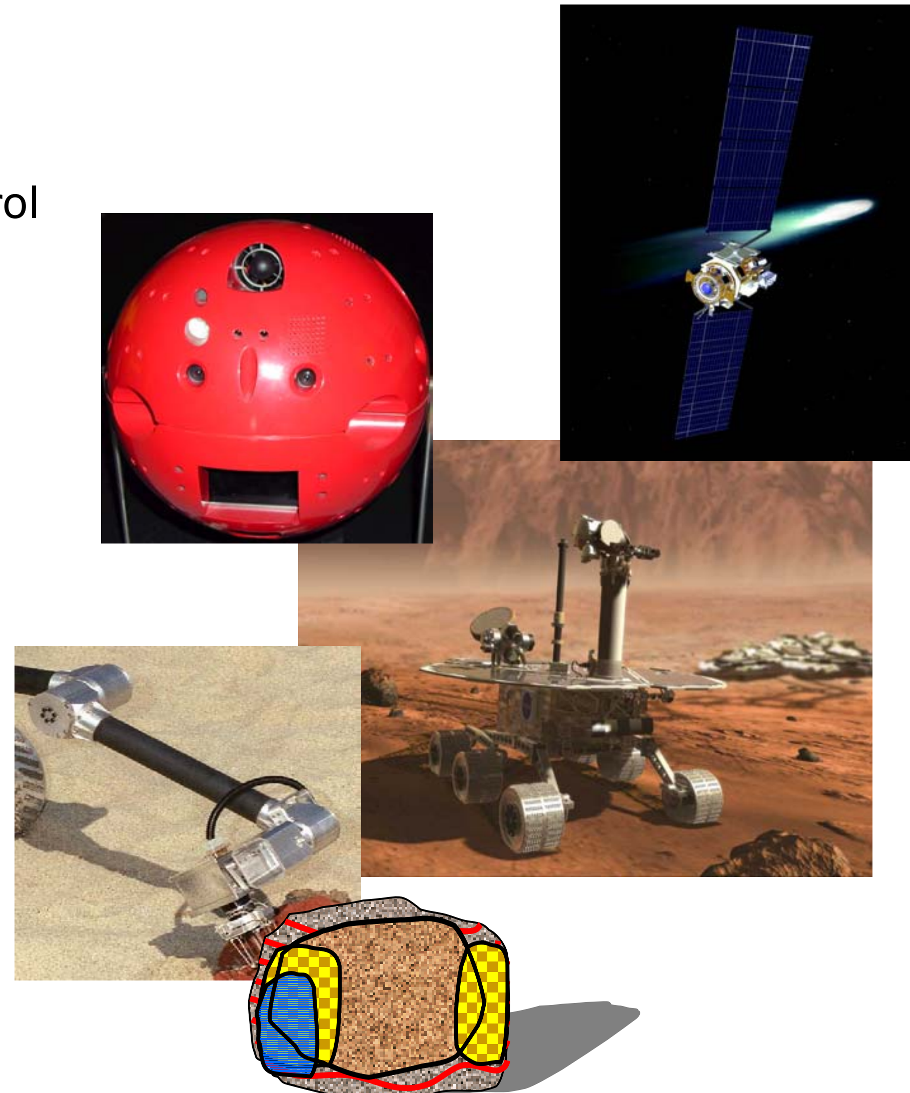
- Planning and Scheduling
- Robust Execution and Adaptive Control
- Adjustable Autonomy

Experience

- Shuttle and Station
- Deep Space One
- Mars Exploration Rover

Insight

- NASA Autonomy Requirements
- Past Success (and Failures)
- Technical and Organizational Challenges



Technical Areas

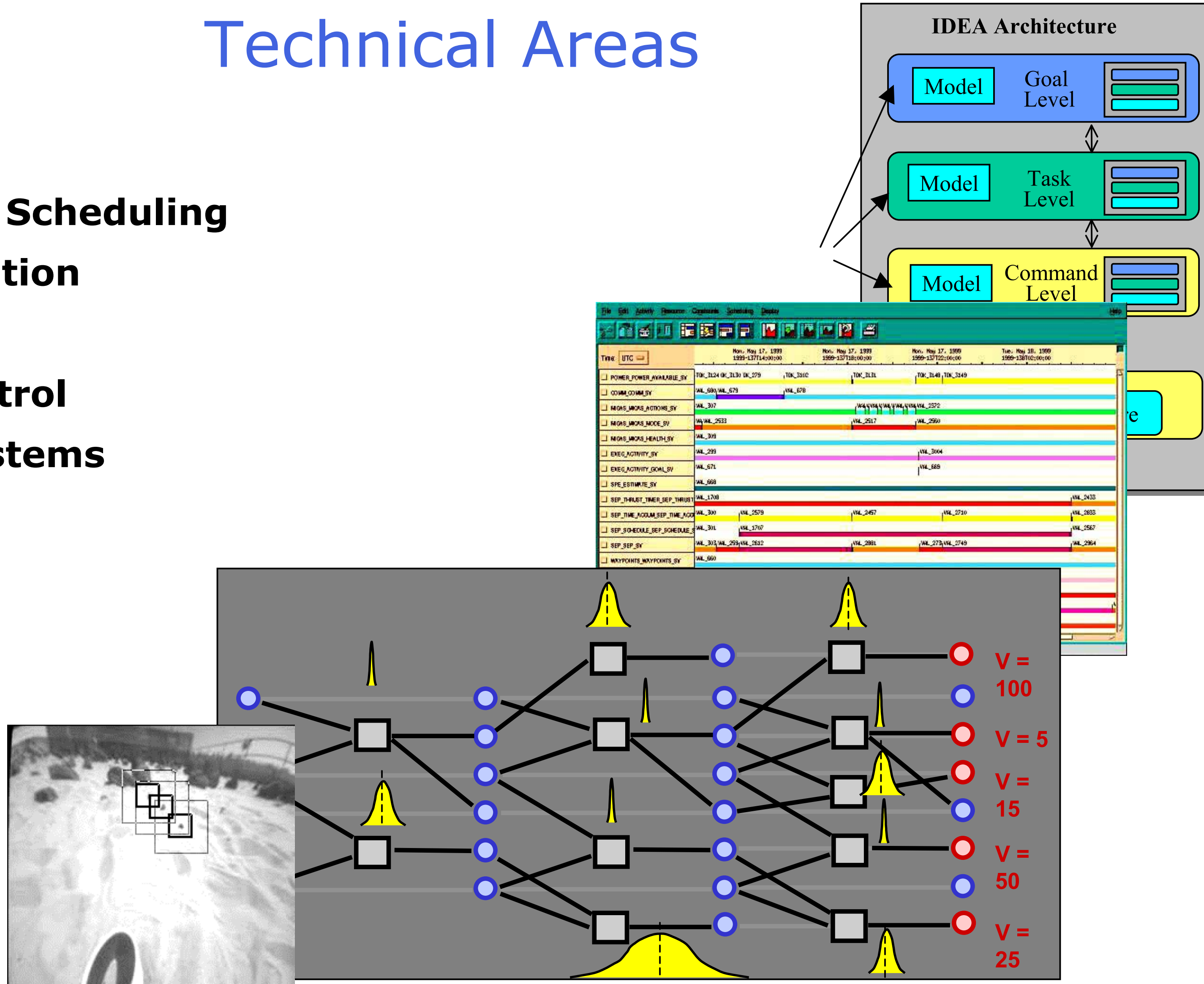
Planning and Scheduling

Robust Execution

Robotics

Adaptive Control

Evolvable Systems



Planning and Scheduling

Core technical strength

Established leadership in technical journals and conferences

Mission track record

Shuttle ground processing – Early application of planning and scheduling to mission cost saving (leading to highly successful commercial spin-off)

Deep Space One – Autonomous onboard planning and replanning

Mars Exploration Rover (MER) – MER science and uplink team members have estimated that **overall science return increased by 20 to 50%.**

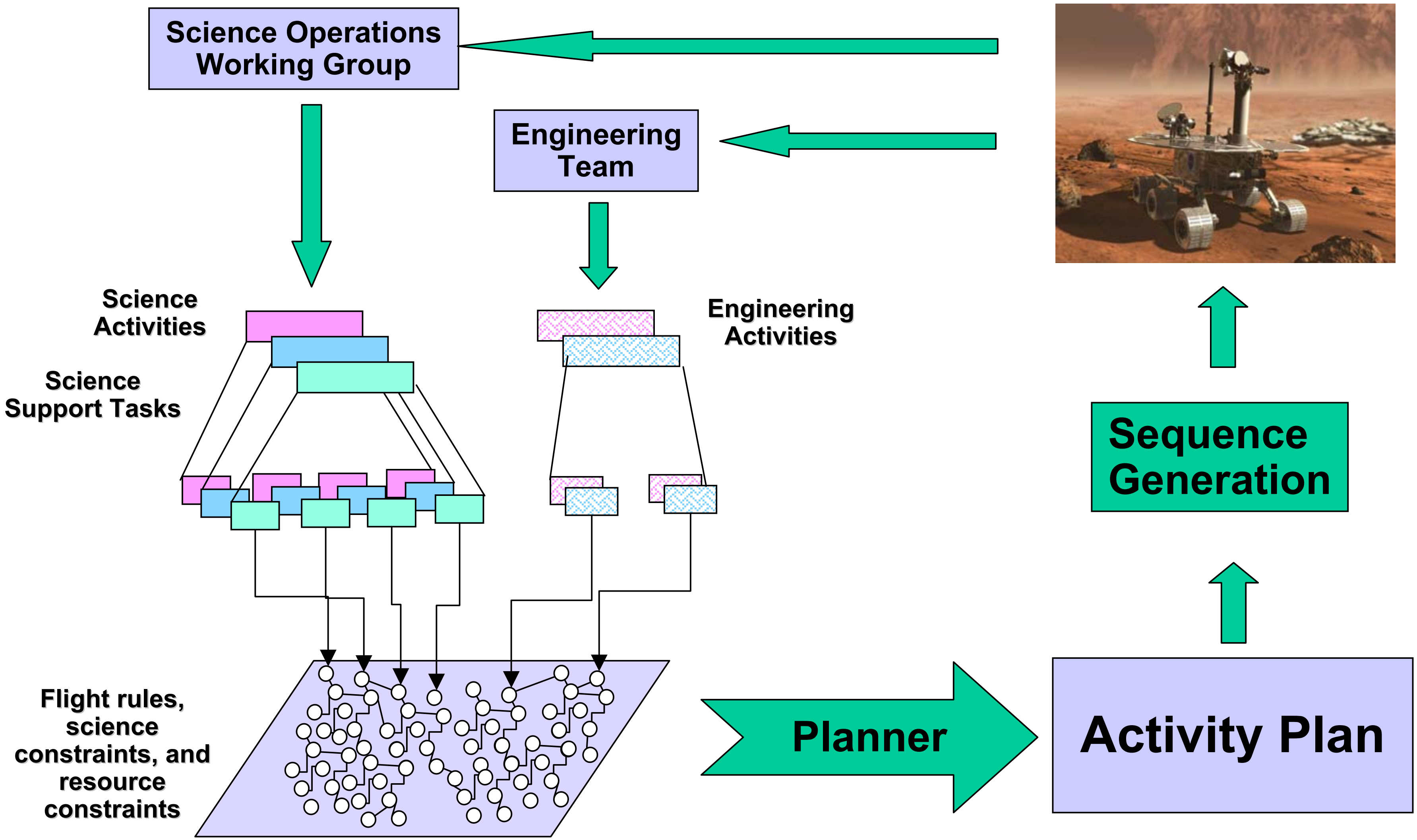
Applications in Exploration

Reduction in mission operations costs

Increased safety through rapid planning and replanning

Specific areas: crew scheduling, robotic activity planning, power system, life support system, etc.

Example: MER Activity Planning



Robust Execution

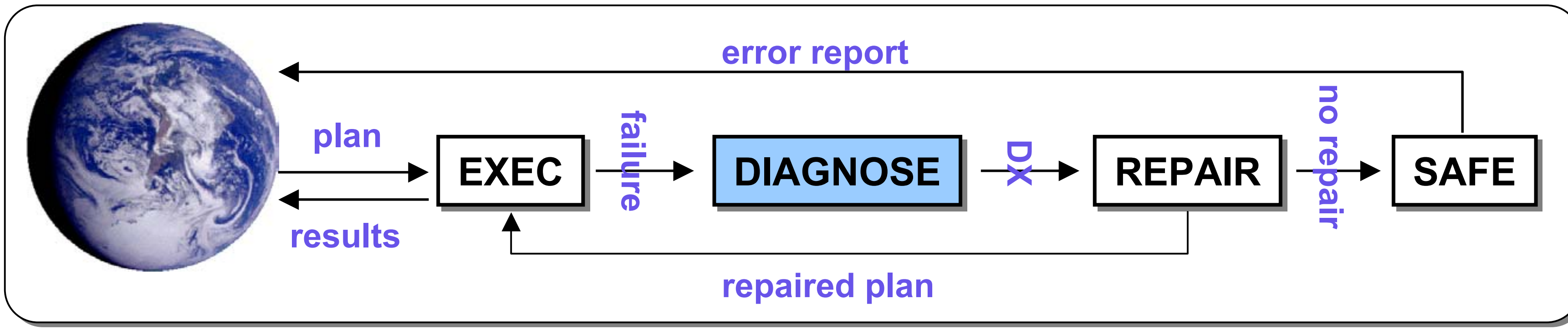
Robust execution is the key bridge between decision-level autonomy and the control level

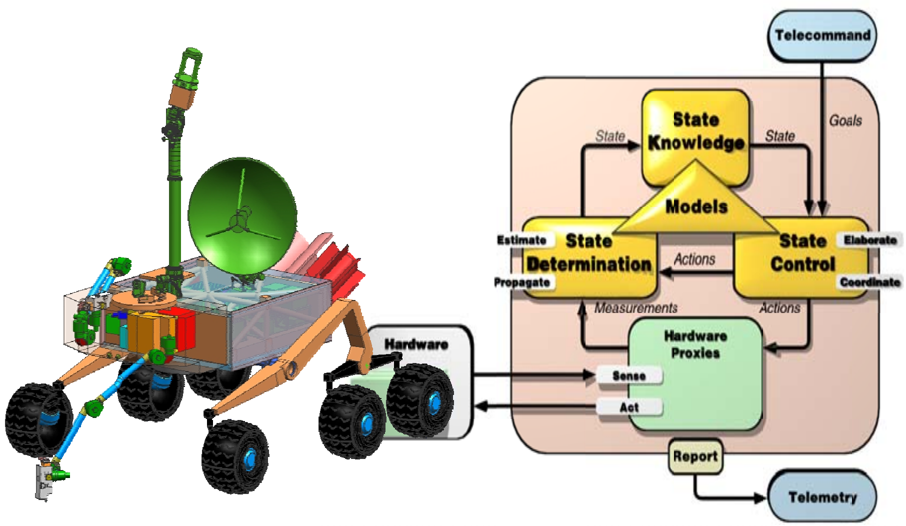
Ames provides robust execution for:

- LORAX and LITA rover field experiments (joint with Carnegie Mellon)
- DAME and MARTE demonstrations of autonomous drilling
- The Ames Autonomous Rotorcraft Project
- K9 Field Demonstration (advanced rover field science)
- Autonomous control agent for the MAM interferometery test bed
- Leadership in creating decision layer for JPL CLARAty architecture
- Many ARC and JPL intramural H&RT proposals

MARTE = Mars Astrobiology Research and Technology Experiment
DAME = Drilling Automation for Mars Exploration
LITA = Life in the Atacama
LORAX = Life On ice: Rover Antarctic Traverse

Example: Advanced Fault Protection System prototype for Mars Science Laboratory (MSL)

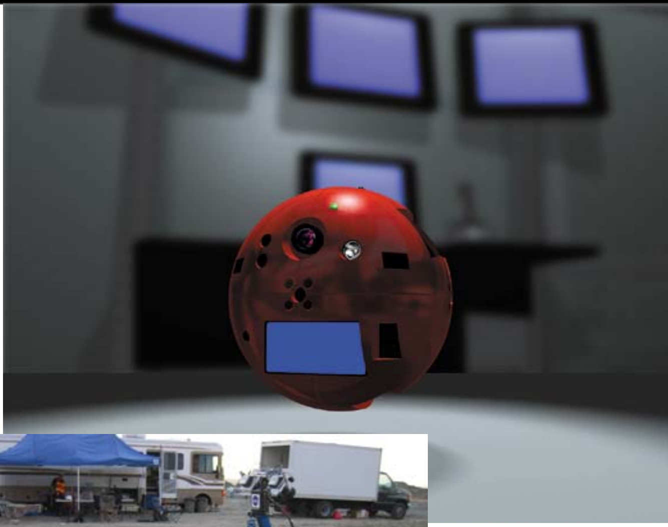




JPL/Ames Partnership

Yields more reliable but less expensive fault protection.

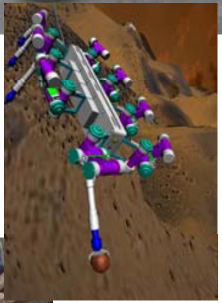
Robotics



Ames has developed the software for multiple robotic systems:

- Personal Satellite Assistant
- K9 Rover
- K10 Rovers (under construction)
- PERs (Personal Education Rovers)
- Scorpion
- MARTE and DAME drilling systems
- Autonomous rotorcraft and fixed-wing aircraft

These systems have been used in multiple field demonstrations



Ames has a strong competence in the integration of autonomy, controls, and hardware in mission relevant tasks

Available as test beds

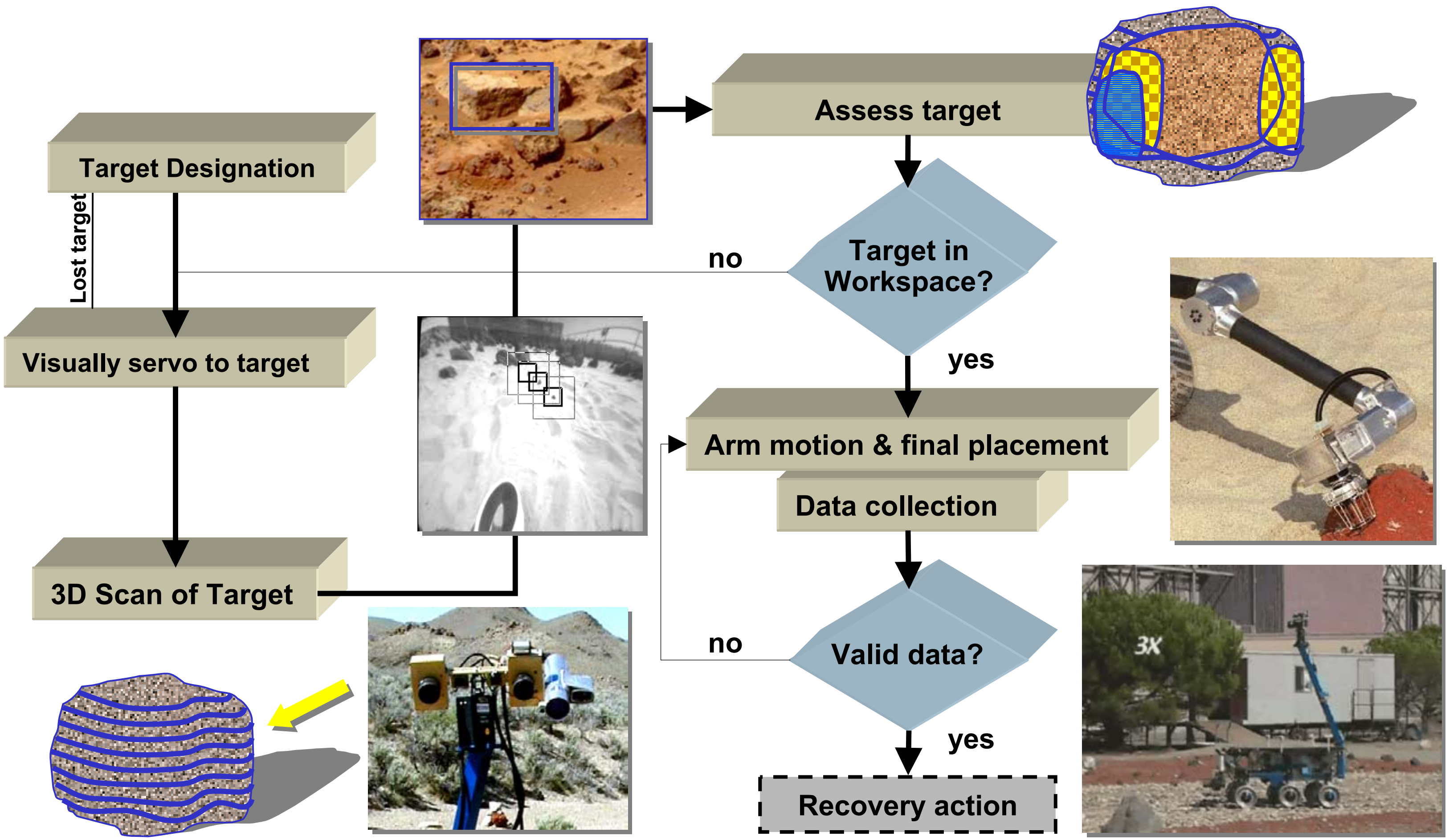
Example: Tele-Robotics

Tele-robotics requirements are driven by latency and the need for one astronaut to control multiple robots

Ames expertise:

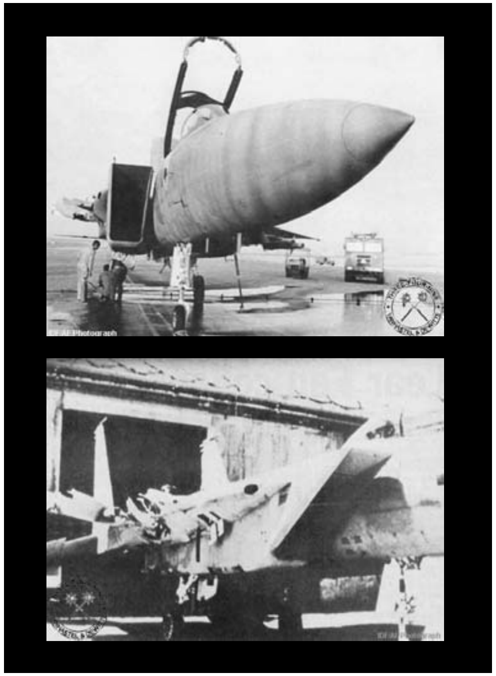
- Predictive interfaces
- Goal-level commanding

Example: Single Cycle Instrument Placement



Terrestrial demonstrations show a theoretical 10x increase in science return vs. the MER rovers.

Adaptive Control



Overview:

- Neural network used to adaptively control aircraft following a catastrophic failure.
- Able to synthesize a new controller in real-time.
- Higher-level control systems continue to operate the vehicle as if it were healthy.

Demonstration:

- Robust simulation-based demonstration.
- Flight experiments on a modified F-15.
- Natural extension to robust control of space craft systems.

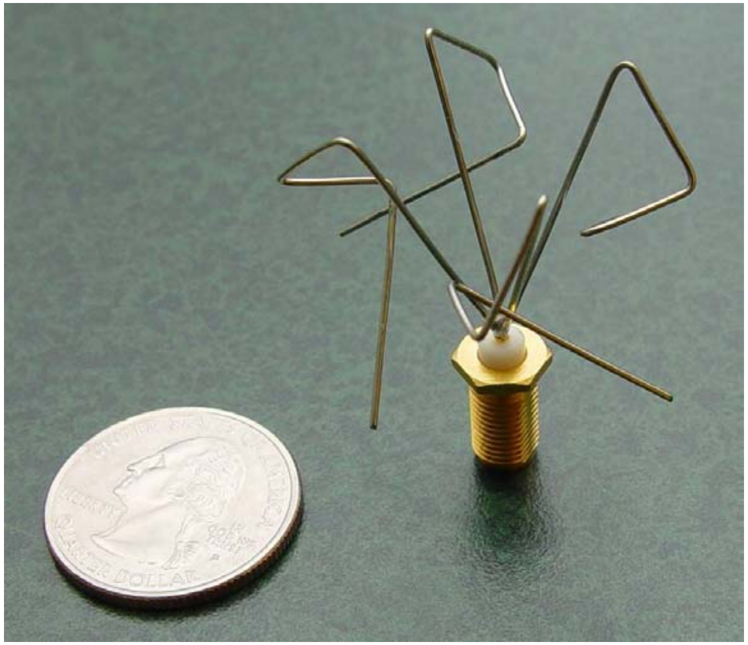
Evolvable Systems

Background: ***Evolutionary algorithms used to search large, unstructured design spaces for a diverse range of applications.***

Antennae Design:

Designed antennae for ST-5 mission that out performed a custom designed antennae by 50%.

Similar results for Mars Odyssey



Reconfigurable FPGA devices:

Algorithms for on-line reconfiguration in response to single event upset.

Designed to provide radiation tolerant computer.

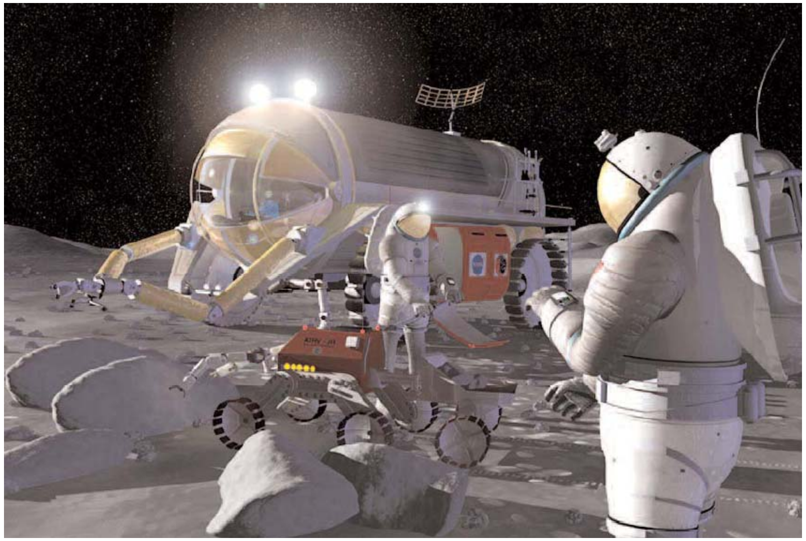
Long term vision:

Evolutionary design for nano-scale devices.

Other Areas

- 6 degree-of-freedom stereo vision and localization (free fliers)
- Educational robotics
- Field robotics
- Multi-agent systems

Wrap Up



Autonomy and robotics are critical to the exploration vision

Ames has extensive experience using autonomy in NASA missions

Technical expertise in key areas of Autonomous Systems and Robotics

- Planning and Scheduling
- Robust Execution
- Adaptive Control
- Robotic Systems